

Claims

1. A radial penetrator assembly for sealingly conducting fluid through the passageway in a wall of a wellhead housing having a central bore and into a port in an inner member positioned within the central bore of the wellhead housing, the radial penetrator assembly comprising:

a flexible tube extending radially between the passageway in the wellhead housing and sealingly engaging the port in the inner member;

a sleeve-shaped adapter extending radially from the wellhead housing and having an adapter bore sealed to the passageway in the wellhead housing; and

a radially outer seal between a radially outer portion of the adapter and a radially outer portion of the flexible tube, such that the flexibility of the tube permits an inner portion axis of the tube to be axially offset or slanted with respect to an outer portion axis of the tube.

2. A radial penetrator assembly as defined in Claim 1, wherein the radially outer seal is a metal-to-metal seal between an outer sealing surface on the flexible tube and an inner sealing surface on the adapter.

3. A radial penetrator assembly as defined in Claim 2, wherein the inner sealing surface on the adapter is tapered for sealing with a tapered surface on the outer seal.

4. A radial penetrator assembly as defined in Claim 2, wherein the outer sealing surface on the flexible tube is substantially cylindrical for sealing engagement with a substantially cylindrical inner surface on the outer seal.

5. A radial penetrator assembly as defined in Claim 1, wherein the inner member comprises a tubular hanger for suspending a tubular string in a well, and the

port in the tubular hanger is a throughport which extends to an end surface of the tubular hanger.

5 6. A radial penetrator assembly as defined in Claim 1, wherein the inner member is positioned on a landing shoulder of the wellhead housing to be at a selected axial position within the central bore of the wellhead housing.

10 7. A radial penetrator assembly as defined in Claim 6, further comprising: a radial alignment member for selectively aligning the inner member within the central bore of the wellhead housing.

8. The radial penetrator assembly as defined in Claim 1, wherein the wellhead housing has a generally cylindrical bore.

15 9. A radial penetrator assembly as defined in Claim 1, wherein the inner member has a generally cylindrical outer diameter.

20 10. A radial penetrator assembly as defined in Claim 1, wherein the port in the inner member includes a throughport extending to an end surface of the inner member.

11. A radial penetrator assembly as defined in Claim 10, wherein an axis of the passageway in the wellhead housing is substantially aligned with an axis of the end port.

25 12. A radial penetrator assembly as defined in Claim 1, wherein the adapter bore is substantially aligned with the passageway in the wellhead housing.

13. A radial penetrator assembly as defined in Claim 1, wherein the outer member has a generally cylindrical outer surface.

14. A radial penetrator assembly as defined in Claim 1, wherein the flexible tube has a substantially cylindrical outer surface along substantially its axial length.

15. A radial penetrator assembly as defined in Claim 1, wherein the radially inner end of the flexible tube is removably sealed with the inner member by an inner plug.

16. A radial penetrator assembly as defined in Claim 15, wherein the inner seal is removably secured to the inner members by threads.

17. A radial penetrator assembly as described in Claim 16, further comprising: an outer seal for sealing between the flexible tube and the adapter, the outer seal being removably secured to the adapter by threads.

18. A radial penetrator assembly as defined in Claim 1, wherein a radial spacing between a radially inner end of the flexible tube and a radially outer end of the flexible tube is in excess of about 30% greater than a radial spacing between a radially inner end of the flexible tube and a radially outer end of the passageway in the wall of the outer member.

19. The radial penetrator assembly as defined in Claim 1, further comprising: a flange assembly sealed to the outer housing and having a port in fluid communication with a cavity in the cover flange which receives an outer portion at the adapter.

20. A radial penetrator assembly for sealingly conducting fluid through the passageway in a wall of a wellhead housing having a generally cylindrical bore and into a port in a tubular hanger positioned within the central bore of the wellhead housing for suspending a tubular string in a well, the radial penetrator assembly comprising:

a flexible tube extending radially between the passageway in the wellhead housing and the port in the inner member;

a sleeve-shaped adapter extending radially from the wellhead housing and having an adapter bore sealed to the passageway in the wellhead housing;

5 a radially outer metal-to-metal seal between a radially outer portion of the adapter and radially outer portion of the flexible tube, such that the flexibility of the tube permits an inner portion axis of the tube to be axially offset or slanted with respect to an outer portion axis of the tube.

10 21. A radial penetrator assembly as defined in Claim 20, wherein the tubular hanger is positioned on a landing shoulder of the wellhead housing to be at a selected axial position within the central bore of the wellhead housing and is rotationally aligned with the outer member by an alignment member.

15 22. A radial penetrator assembly as defined in Claim 21, further comprising: a rotational alignment member for rotationally aligning the tubular hanger within the central bore of the wellhead housing.

20 23. A radial penetrator assembly as defined in Claim 10, further comprising: an outer seal for sealing with the outer sealing surface on the flexible tube and the inner sealing surface on the adapter

25 24. A radial penetrator assembly as defined in Claim 23, wherein the inner member comprises a tubular hanger for suspending a tubular string in a well and the port in the tubing hanger is a throughport which extends to an end surface of the tubular hanger.

25. A radial penetrator assembly as defined in Claim 23, wherein the outer sealing surface on the flexible tube is substantially cylindrical for sealing engagement with a substantially cylindrical inner surface on the outer plug.

5 26. A radial penetrator assembly as defined in Claim 20, wherein the port in the inner member includes a throughport extending to an end surface of the inner member.

10 27. A radial penetrator assembly as defined in Claim 20, wherein an axis of the passageway in the wellhead housing is substantially aligned with an axis of the end port.

 28. A radial penetrator assembly as defined in Claim 20, wherein the adapter bore is substantially aligned with the passageway in the wellhead housing.

15 29. A radial penetrator assembly as defined in Claim 20, wherein the radially inner end of the flexible tube is removably sealed with the tubular hanger by an inner seal.

20 30. A radial penetrator assembly as defined in Claim 29, wherein the inner seal is removably connected to the tubular hanger by threads.

31. A radial penetrator assembly as defined in Claim 29, further comprising:
an outer seal for sealing between the flexible tube and the adapter, the outer seal
being removably sealed to the adapter by threads.

5 32. A radial penetrator assembly as defined in Claim 20, wherein a radial
spacing between a radially inner end at the flexible tube and a radially outer end of the
flexible tube is in excess of about 30% greater than a radially spaced between a radially
inner end of the flexible tube and a radially outer end of the passageway in the wall of
the outer member.

10 33. A radial penetrator assembly as defined in Claim 20, further comprising:
a flange removably sealed to the outer housing and having a port in fluid
communication with a cavity in the flange which receives an outer portion of the
adapter.

15 34. A method of sealingly conducting fluid through the passageway in a wall of
a wellhead housing having a central bore and into a port in an inner member positioned
within the central bore of the wellhead housing, the method comprising:

20 radially extending a flexible tube between the passageway in the wellhead
housing and the port in the inner member;

providing a sleeve-shaped adapter extending radially from the wellhead housing
and having an adapter bore sealed to the passageway in the wellhead housing; and

25 forming a radially outer seal between a radially outer portion of the adapter and
radially outer portion of the flexible tube, such that the flexibility of the tube permits an
inner portion axis of the tube to be axially offset or slanted with respect to an outer
portion axis of the tube.

35. A method as defined in Claim 34, wherein the radially outer seal is a metal-to-metal seal formed between an outer sealing surface on the flexible tube and an inner sealing surface on the adapter.

5 36. A method as defined in Claim 34, wherein the inner member is positioned on a landing shoulder of the wellhead housing to be at a selected axial position within the central bore of the wellhead housing.

10 37. A method as defined in Claim 36, further comprising:
providing a rotational alignment member for rotationally aligning the inner member within the central bore of the wellhead housing.

15 38. A method as defined in Claim 34, further comprising:
providing an outer seal for sealing with the outer sealing surface on the flexible tube and the inner sealing surface on the adapter.

20 39. A method as defined in Claim 30, further comprising:
tapering the inner sealing surface on the adapter for sealing engagement with a tapered surface on the outer seal.

40. A method as defined in Claim 38, wherein the outer sealing surface on the flexible tube is substantially cylindrical for sealing engagement with a substantially cylindrical inner surface on the outer seal.

25 41. A method as defined in Claim 34, wherein an axis of the passageway in the wellhead housing is substantially aligned with an axis of the end port.

42. A method as defined in Claim 34, wherein the radially inner end of the flexible tube is removably sealed with the inner member by an inner seal.

43. A method as defined in Claim 34, wherein an inner seal is removably sealed to the inner member by threads.

5 44. A method as defined in Claim 43, further comprising:
providing an outer seal for sealing between the flexible tube and the adapter, the
outer seal being removably secured to the adapter by threads.

10 45. A method as defined in Claim 34, wherein a radial spacing between a
radially inner end of the flexible tube and a radially outer end of the flexible tube is in
excess of about 30% greater than a radial spacing between a radially inner end of the
flexible tube and a radially outer end of the passageway in the wall of the outer member.

15 46. A method as defined in Claim 34, further comprising:
removably sealing a flange to the outer housing and having a port in fluid
communication with a cavity in the flange which receives an outer portion of the
adapter.

20 47. A method as defined in Claim 34, wherein the port in the inner member
includes a throughport extending to an end surface of the inner member.

48. A method as defined in Claim 34, wherein test fluid is introduced to verify
holding of a selected working pressure.